Maize Yield Gains from Seasonal Forecasts using the CCAFS Regional Agricultural Forecasting Toolbox (CRAFT)

Andree Nenkam[1*], Sibiry Traore[1], Vakhtang Shelia[2], Sridhar Gummadi[1], James Hansen[3], Anthony Whitbread[1] and Gerrit Hoogenboom[2]

[1]International Crops Research Institute for the Semi-Arid Tropics (ICRISAT); [2]Department of Agricultural and Biological Engineering & Institute for Sustainable Food Systems, University of Florida, Gainesville, FL, USA ; [3]CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS); International Research Institute for Climate and Society(IRI), Columbia University, NY, USA.

Introduction

- 'Maizification' of Sudan savanna from agricultural intensification may increase exposure to inter-annual climatic risk.
- Erosion of traditional staples dominance will increase dependence on inputs (despite low availability of agricultural resources), and externalization of climate risk management, e.g. through use of SCFs.
- Improvements in integrated climate and crop modeling, gridded data offer new possibilities for yield forecasting through the CCAFS Regional Agricultural Forecasting Toolbox (CRAFT) to optimize resource allocation and thus improving food security.

Objectives

- Evaluate CRAFT and assess the sensitivity of the maize cropping systems in Southern Mali to recent climate variability at different spatial and temporal scales;
- Evaluate its potential for crop yield forecasting;
- Investigate its benefit for planning and decision-making at regional level.

Materials and methods

Data

- 26 years (1990-2015) observed yield aggregated to the third administrative unit (28 districts) spanning over 5 regions (**Fig 1**).
- 2008 farmers' observed management practices, namely fertilizer application amount and dates.
- CRAFT input data: weather (rainfall, temperature and solar radiation), management practices (crop, sowing details, fertilizer), soil information, and crop masks.

Table 1: Fertiliser Scenarios	Average N(kg/ha)	Days after Sowing
F1 (aggregated at regional level)	42	23 & 38
F2 (recommended)	61	15 & 45

Methodology

- Two fertilizer scenarios were designed for sensitivity analysis and hindcast results validation (Table 1)
- CRAFT was used to generate Yield forecast for two regions, Fana and Sikasso, and compared against 2015 and the long-term mean (1990-2014) of observed yield;
- The predictors used were the sea surface temperature (SST) covering the Atlantic ocean and known to have an impact on the rainy season in the West Africa.

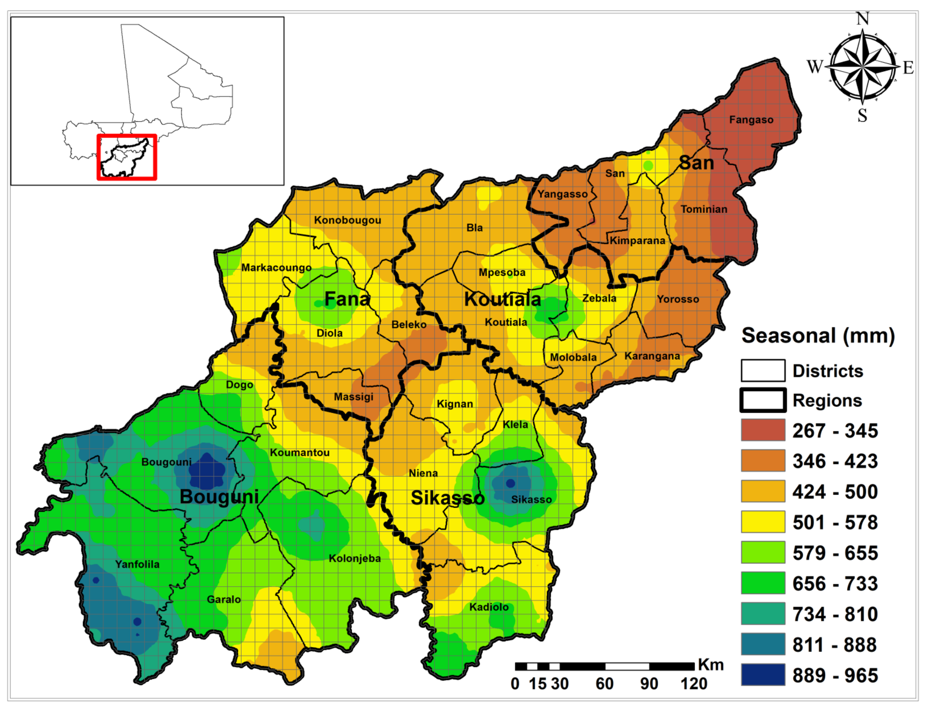

Fig 1. Average (1990-2014) seasonal rainfall distribution across the study area

Sensitivity Analysis

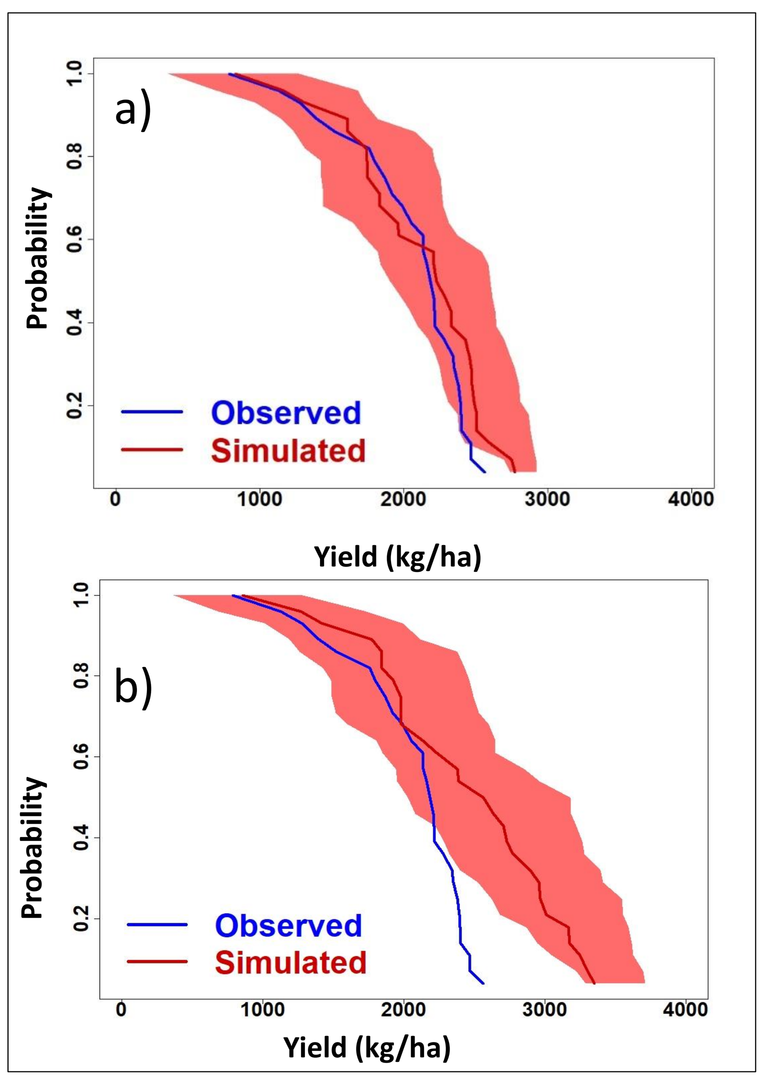

Fig 2. Exceedance probability graph of CRAFT estimated yield against observed yield for the 28 districts. a) F1; b) F2

NB: The red area represents the spread of the simulated yield from the 25th to the 75th percentile

- CRAFT simulated yield from F1 are closer to the observed (**Fig 2, Fig 3**); however F4 has a slighter better relationship with the observed having a higher coefficient of determination (**Fig 4**).
- CRAFT results from F1 has a higher accuracy with an RMSE of 389 kg/ha against 613 kg/ha for F2, respectively representing 19% and 30% of the long-term mean (1990-2015) of the observed .
- Results from both F1 and F2 reveal that CRAFT is better at estimating lower yield.
- The current management practices limits the potential of the different maize varieties, because production could have increased if the recommended (F2) management was used. Maybe this is possible for higher rainfall areas to optimize the use of the rains by the inorganic fertilizer. Resource allocation may then be increased for those areas.

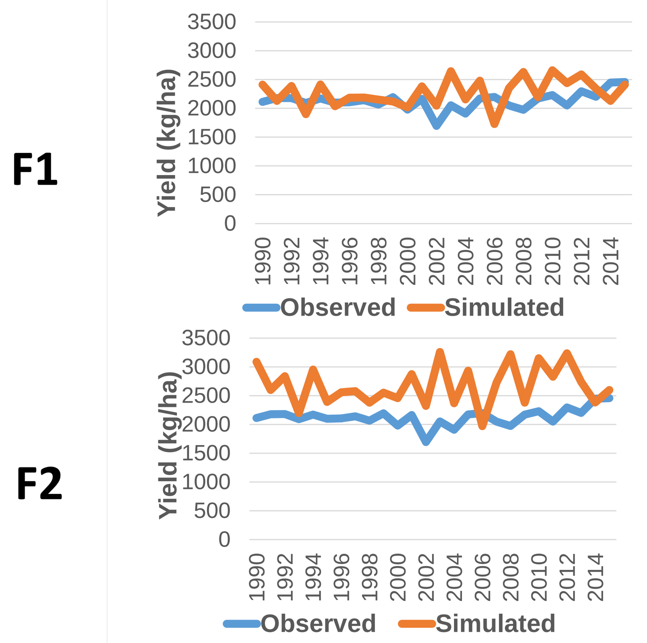

Fig 3. CRAFT (averaged) estimated and observed yield across the CMDT region

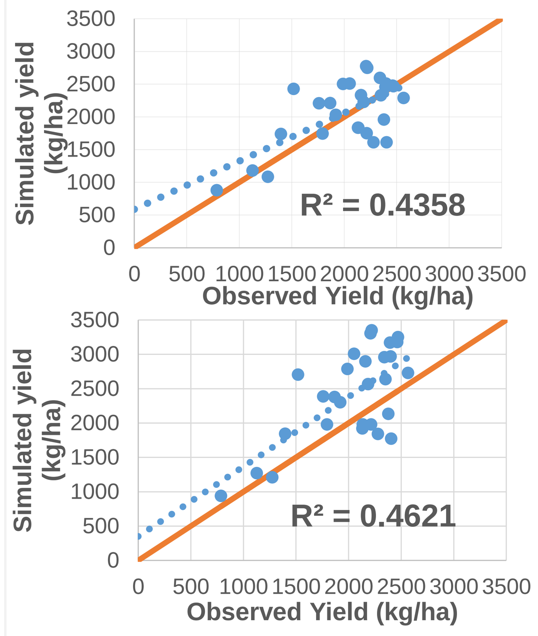

Fig 4. Comparison between CRAFT and maize averaged observed yield for the 28 districts

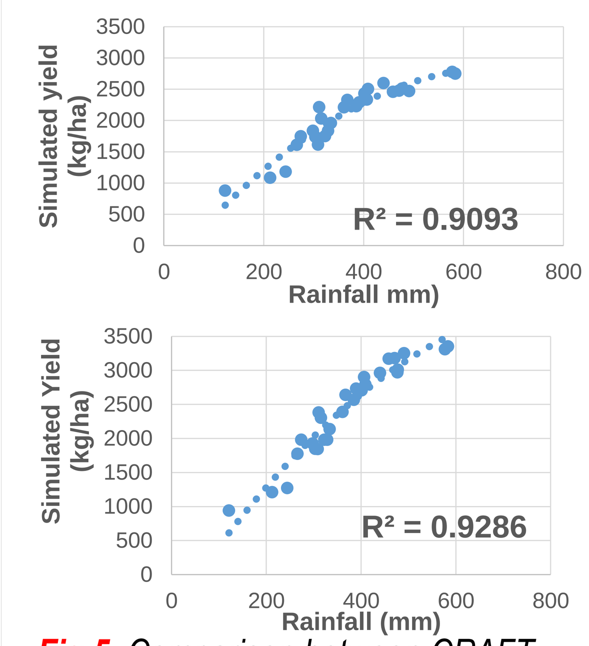

Fig 5. Comparison between CRAFT yield and rainfall from sowing to harvest for the 28 districts

Yield Forecast

- 2015 yield forecasted results by CRAFT varied for each fertilizer scenarios and at different lead times (5 to 2 months prior to harvest). Crop harvest in the region occurs in October.
- Yield from both F1 and F2 were mainly predicted to decrease by up to 49% and 45% respectively 2 months prior to harvest, this reduction increases as the forecast is generated closer to the harvest period using up to date predictors (**Fig. 6**).
- On the other hand, CRAFT projected increase in yield, for 2015 cropping season, by up to 50% (3 months prior to harvest) and 36 % (4 months prior to harvest) for F1 and F2 respectively.

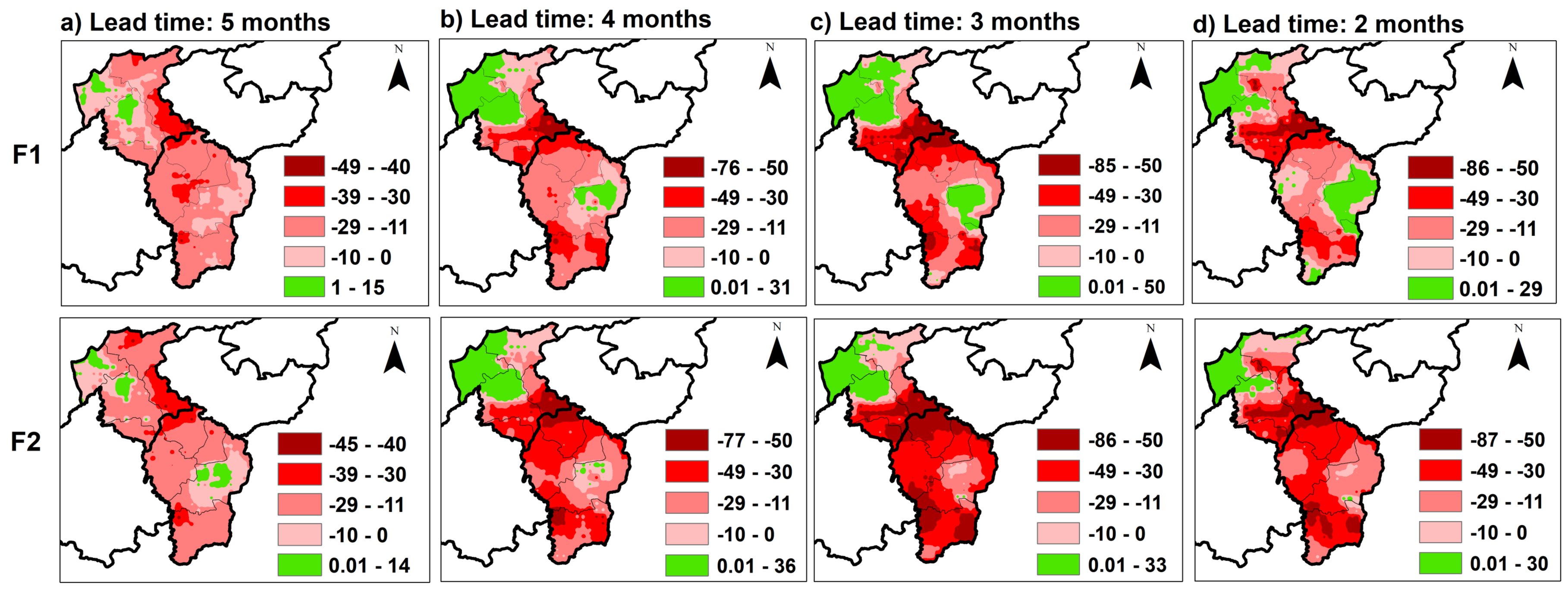

Fig 6: Deviation (%) of the forecasted yield (2015) from the observed (2015) at different lead times using F1 and F2

- The highest accuracy of the 2015 yield forecast, is identified 5 months prior to harvest (**Table 2**).
- Sikasso's huge yield decrease with F2, despite having a wetter climate, incurs that decision makers should continue with their current agricultural resource allocation in that region.
- Yield increase occur particularly in area having long-term average seasonal rainfall above 500 and 600 mm in Fana and Sikasso regions, respectively (**Fig 1, Fig 6**). Maybe CRAFT functionalities should be reviewed and/or improved for higher rainfall areas.

	F1			F2		
	RMSE (kg/ha)			RMSE (kg/ha)		
Lead time (month)	Absolute value	% of mean observed	CV (%)	Absolute value	% of mean observed	CV (%)
5	530	22%	13%	548	23%	15%
4	604	25%	16%	773	32%	16%
3	749	31%	19%	1031	43%	22%
2	588	24%	22%	881	36%	19%

Table 2: Accuracy of the 2015 yield forecast against the 2015 observed yield

Conclusions & Perspectives

- Results suggest that more improvement is needed on CRAFT yield forecast procedure for wetter climate
- CRAFT is being developed to predict regional level yield outcomes and food security. Such a tool can assist governments make pre-season procurement of imports or in the case of a deficit year, grain imports or food aid.
- CRAFT Yield forecasting results are influenced by the types of predictors. Future work will consist of exploring results behavior with other predictors such as wind fields and sea surface temperature from other areas.

References:

- **Hansen, J. , 2013.** The CCAFS Regional Agricultural Forecasting Toolbox (CRAFT).
- **Shelia et al., 2019.** A multi-scale and multi-model gridded framework for forecasting crop production, risk analysis, and climate change impact studies, Environmental Modelling & Software.

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* a.nenkam@cigar.org

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